Encapsulation Technologies for Bio Inoculation of Fungicides

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Introduction

Keeping a tab on the agricultural production systems on a maintained level is a challenge for the future as the Indian population is increasing at a rapid pace. Plant diseases cause considerable losses in crop production and storage Chemical pesticides are commonly used to control pests, which cause harmful impacts on the environment and non-target living systems, including human beings. Bio-pesticides are natural and a better substitute for chemical pesticides and provide an alternative for crop protection worldwide. The trend of bio-pesticides consumption in India has shown a drastic increase in use over time which stood at 8,647 and 8,898 metric tons in 2020-21 and 2021-22, respectively Although the value of eco-friendly pest management in sustainable agriculture has been well recognized, only very little is being adapted at the field level. But making it reach to the field with a suitable delivery method maintaining consistent performance is the next most important challenge. The bio-agents cannot be applied as spore suspension in field but are applied as powdered or liquid formulation primarily through seed treatment, soil application, root dip or foliar application, encapsulation etc. In India, as compared to chemical pesticides, bio-pesticides production, utilization, and consumption are much lower due to a lack of research advancements, innovation and policies. To increase the use of bio-pesticides at the country level, it is necessary to understand their mode of action, contribution to sustainable agriculture and their effects on human health and plant diseases.

Therefore, strategies to limit fungicide usage have gained paramount importance. Owing to their antagonistic activity against various pathogenic fungi, bio-agents emerged as prospective candidates for enhancing both the effectiveness and sustainability of plant protection. Nevertheless, the utilization of bio-control agents like Trichoderma, Penicillium has unveiled new challenges, notably their vulnerability to physical stimuli and diminished efficacy during prolonged storage. To overcome these drawbacks, present a mild and scalable encapsulation method employing a layer-by-layer (LbL) encapsulation approach using bio-based lignin derivates results in remarkable improvements in spore stability, even under adverse conditions such as variable temperature and prolonged exposure to UV irradiation compared to unencapsulated spores. Notably, encapsulated spores exhibit increased efficiency in the cultivation of plants when compared to their unencapsulated counterparts. Additionally, efficacy of encapsulated spores is contingent upon the specific strain employed. The results outlined herein suggest that Trichoderma spores, encapsulated within lignin through the LbL approach, exhibit potential as promising and sustainable alternative to chemical fungicides and potential commercialization.

Encapsulation technologies

In formulation technology, encapsulating microorganisms in a polymeric matrix is presently under experimentation. Encapsulation is creating a film or encasing microbial cells in a polymeric material to yield beads that are permeable to minerals, gases, and metabolites while permitting cellular activity to persist inside the beads (Bashan *et al*. 2014, John *et al*.2011). Two approaches are employed depending on the mass of the beads that are produced macro encapsulation (involving beads that are millimeters to centimeters in size) and microencapsulation (involving beads that are 1-1000 μm in size). Bio-encapsulation as a carrier provides a protective environment during field and storage and assists the slow release of microbes with the usage of encapsulation, particularly suitable for soil applications, microorganisms may be prevented from biotic and abiotic stress factors like contaminants, antagonists or dryness and may proliferate at the site of application due to the beneficial microenvironment provided by the formulation (Vemmer and Patel, 2013)

Among the available polymers, alginate has been the most preferred maternal for most of the encapsulated formulations According to Vassilev *et al* (2005), there are at least 1,350 combinations of natural, semi-synthetic, and synthetic polymers for the entrapment of biomaterials, but the majority of techniques involved in situ entrapment by using natural polysaccharide gels which include alginates, agar, and carrageenan. The formulation provides a temporary shelter for the encapsulated strain from the sol environment and microbial competitors, both hostile to any change in the biological makeup of the sod. Any premature release of microbes from these encapsulated forms is detrimental because the main purpose of these formulations is to sustain the entrapped cells in an active phase for as long as feasible at high concentrations as nutrients and oxygen are easily accessible to a strain due to simple diffusion, the shelf life increases The viability of microbes is higher in the case of encapsulation as controlled release to the external environment minimizes the wastage of microbial cells. Minimum storage space is required as it is immobilized in micro or macro beads.

Seed Encapsulation

It is a specialized seed coating process which involves enveloping the seed microbes, and possibly line other components such as pesticides or micronutrients, in a gelatinous or polymer gel matrix, thereby prolonging the survival of microbial inoculants on seed the gel like matrix allows the coil to remain viable with its catalytic ability for longer duration. This method of delivery system has a distinct advantage of being user trendy and environmentally sale, since the active ingredients are effectively sealed until they are released during germination, Major factors that need to be taken care of while adopting this technique are seed inoculum density, coating stability, both for microbes, viability and coat integrity, in association with user feasibility and cost of production.

Conclusion

The increasing concern of consumers on the one hand and government on the other hand about the problems associated with synthetic chemicals for pest control and in food safety has led growers to find new eco-friendly methods to replace the current chemical-based practices. The use of biopesticides as supplement has emerged as a promising alternative to chemical pesticides and their demand is increasing steadily in all parts of the India. Farmers would be able to accept biopesticides better if they were able to grow organic farming and produce that is free of pesticide residue. The research into biopesticides is still in its infancy and is in need of more attention and reliability. The challenges in broad usage of biopesticides in India are related to the efficacy, shelf-life production methods, narrow range of host or target pathogens/pests, poor performance in the field, problems in the delivery system, economics, and regulations.

In this context, discovery of new substances and research on formulation and delivery would boost commercialization and use of biopesticides. However, a commitment to the development of high-quality products, a more responsive registration process and government support for research, extension and productive collaboration among researchers, industry, and farmers will help biopesticides to gain more mainstream acceptance in sustainable crop production practices.

References

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